IRRIGATION AND ENVIRONMENTAL CHANGE IN MEDITERRANEAN WETLANDS
THE SEGURA RIVER DELTA FROM THE 10TH TO THE 19TH CENTURY

Pablo Giménez Font / *University of Alicante*
pablo.gimenez@ua.es

This study is concerned with understanding the impact of the cause and effect relationships on the complex environmental history of the Mediterranean wetlands. A case study of the Segura River Delta (south east of the Iberian Peninsula) allows a direct relation to be established between human impact and delta growth, which was notably significant during the Modern Ages. Together with a series of specific natural conditions (LIA and neotectonic), the constitution of this zone as an irrigated landscape directly affected the nature of the wetlands in the distal areas of the delta.

INTRODUCTION AND METHODOLOGY

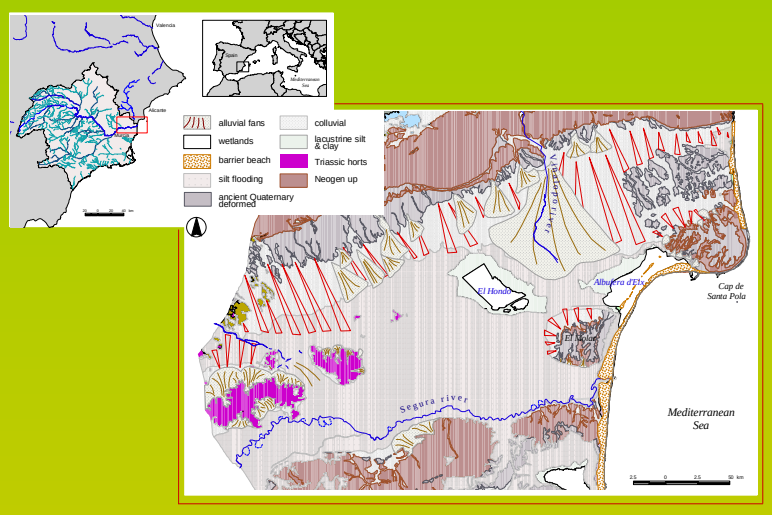


Figure 1: Study area in the drainage network of the Segura River basin (SE Spain). Geomorphological map.

The aim of this study is to analyse the important changes in land use in the delta over the last 300 years as well as their environmental repercussions on the wetlands. For this purpose, a reconstruction of the way the delta has evolved since the 10th century has been performed based on previous geoarchaeological and sedimentary information (Gutiérrez *et al*. 1999; Echallier, 2000; Barrier *et al*., 2004) and a detailed documentary analysis of events since the 17th century has been carried out (Giménez-Font, 2008).

The Segura River has a watershed basin (14.925 km²) which ends in a flood plain where the alluvial fan also converges with the Vinalopó River (temporary stream). Both rivers are subject to occasional flash flooding with a consequently high level of sedimentation. Neotectonic activity is intense (subsidence).

Figure 2: Holocene evolution. Marsh and lagoon for 4000 BP

During the middle and high Holocene, this confined delta showed the following evolution: since the last post-glacier period (6500-6000 BP) a series of prograding phases have occurred in the Delta related to the lowering sea level, neotectonics, reactivation of continental sedimentation and the formation of sandbars and barrier beach. From approximately the year 4000 BP and as a result of these sandbars, a flood plain began to form with a series of landlocked lagoons (Blazquez & Usera, 2004; Gutiérrez *et al*. 1999)

RESULTS: CHANGING SCENARIOS IN LAND USE AND DELTA GROWTN

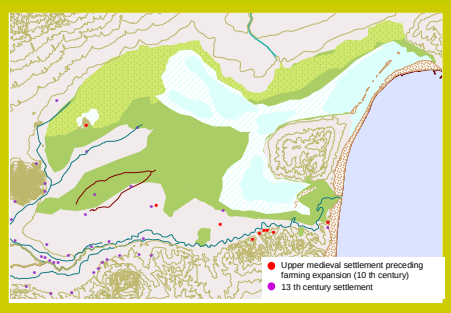


Figure 3. 10th-11th centuries

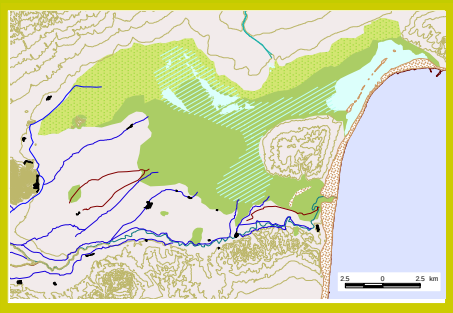


Figure 4. final 17th century

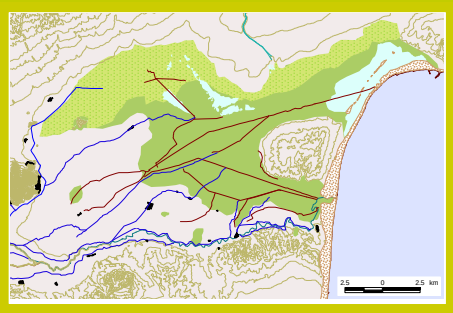


Figure 5. AD 1720

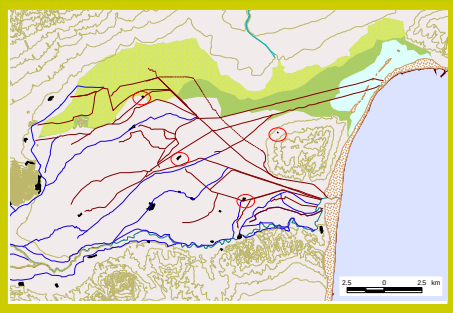
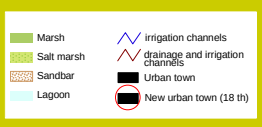


Figure 6. AD 1817

Between the 10th and 11th centuries (under Islamic rule), large irrigation projects were being launched in the marshes and lagoons. In these areas, economic use was based on the natural resources found: hunting, fishing, farming, cattle raising and micro irrigation. By the 17th century (after 300 years of Christian rule), the irrigation areas had grown and the mining activities had entered into crisis and become marginal. Finally, at the beginning of the 18th century, the economic, political and natural conditions were suitable for the undertaking of a large colonisation project directed by the church and supported by the monarchy. In less than a century, 6.300 ha of wetlands and lagoons were converted into irrigated farmland (traditional irrigation area in 1844 = 19.556 ha).



DISCUSSION: DELTA GROWTH AND WETLANDS IN RELATION TO ENVIRONMENT AND HUMAN CULTURES

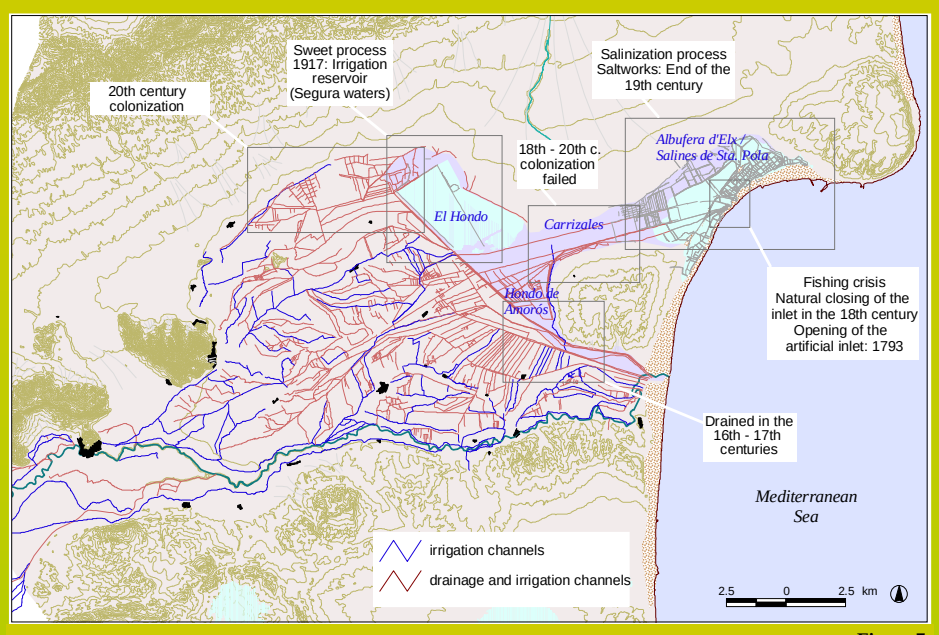
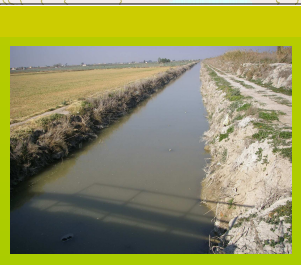


Figure 7

Natural (a) / artificial (b) inlets. *Albufera d'Elx*

"Huerta" landscape



Drainage channel

Albufera d'Elx: saltworks at present

Segura Delta: Catastrophic flood in 1987

Dating large-scale agricultural expansion facilitates an understanding of environmental consequences and the interpretation of certain combined dynamics, such as the possible relationship between the final phase of delta construction and the history of the agricultural system developed in the Segura River delta (Brückner, *et al*. 2005). The changing scenarios in land use could explain, in environmental terms, the delta's configuration today.

3.1 Climate context and tectonic subsidence

The "Little Ice Age" had geomorphological consequences (Grove & Rackham, 2001). Analysis of the catastrophic flooding of the Segura River (flood series 1292-1971) identifies three great climatic changes characterised by the number and dimension of the floods: 1570-1630, 1760-1800 and 1830-1870 (Barriendos & Martin-Vide, 1998). All of these coincide with periods of agricultural growth and deforestation in the Segura Basin. The increase in continental sedimentation reduces the extension and depth of wetlands and the growth of coastal sandbars, thus blocking the feeding of sea water into the wetlands. The regional tectonic conditions were characterised by their activity, not only at the mouth of the Segura River but also in the salt flats of Santa Pola (differential vertical accretion is 0,1 mm/yr.) (Echallier, 2000).

3.2 Human context

The beginning of macrosystem irrigation dates back to the 10th-11th centuries (Gutiérrez, 1995), although settlements continued around the wetlands. The cultural change that came about after the Christians had reconquered Spain (13th - 14th century) coincided with the expansion of irrigation, but it was not until the 17th and 18th centuries that the social and economic conditions were suitable for this expansion to be developed to its full potential. A change in human settlements was produced as well as in the way natural resources were exploited, as can be seen in the clash between agricultural and "aquatic" cultures. We believe that there was also an ecological cause involved in this process: delta growth, silting of the wetlands and enclosure due to the sandbars. Irrigation changed the way the wetlands received feeding water.

CONCLUSION

The evolution of the wetlands over the last 300 years has been influenced by a direct relationship between environmental changes (sea level, sedimentation and neotectonics) and human action (changes in land use):
-The progressive superficial descent of the wetlands has continued naturally with the lowering the sea level and increasing sedimentation. However, irrigation systems and artificial drainage have accelerated this process. Together with the climatic characteristics of the LIA, the harmful actions carried out in the Segura River Basin should be considered at this time.
-The increasing sandbanks and resulting enclosure has disconnected the wetlands from the sea. Maximum exploitation of the river and temporary streams has reduced the amount of freshwater feeding into the wetlands. Leftover irrigation water is directed towards the mouth of the River Segura. Fishing activity has reduced and salinity has increased. In the 19th century, the *Albufera d'Elx* (*Salines de Santa Pola*) turned into salt flats.

References
BARRIENDOS, M. & MARTIN-VIDE, J. (1998): "Secular climatic oscillations as indicated by catastrophic floods in the spanish mediterranean coastal area (14th-19th centuries)" *Climatic Change*, 38: 473-491.
BARRIER, P.; MONTENAT, C.; ROUILLARD, P. (2004): "Paysage protohistorique de l'embouchure du Segura: approche paléogeographique et environnementale" in *Evolución paleoambiental de los puertos y fondeaderos antiguos en el Mediterráneo Occidental*. Roma: Rubbettino, pp. 231-246
BRÜCKNER, H.; VÖTT, A.; SCHRIEVER, A.; HANDL, M. (2005): "Holocene delta progradation in the eastern Mediterranean – case studies in their historical context" *Méditerranée*, 1.2: 95-105
BLÁZQUEZ, A.M. & USERA, J. (2004): "Ensayo de síntesis sobre la evolución cuaternaria de l'Albufera d'Elx" *Geo-Temas*, 7: 129-132.
ECHALLIER, J.C. (2000): "Analyse des sondages géomorphologiques réalisés dans le secteur de Santa Pola – La Marina" in *Le site antique de La Picola (Alicante, Espagne)*, Paris-Madrid: Casa de Velázquez, pp. 70-71.
GROVE, A.T. y RACKHAM, O. (2001): *The Nature of Mediterranean Europe. An Ecological History*. New Haven, CT: Yale University Press, 384 p.
GIMÉNEZ-FONT, P. (2008): *Las transformaciones del paisaje valenciano en el siglo XVIII. Una perspectiva geográfica*. València: Edicions d'Alfons el Magnànim, 460 pp.
GUTIÉRREZ, S. (1995): "El origen de la huerta de Orihuela entre los siglos VII y XI. Una propuesta arqueológica sobre la explotación de zonas húmedas en el bajo Segura" *Arbor* CLI, 593: 65-93.
GUTIÉRREZ, S. *et al*. (1998-1999): MORET P.; ROUILLARD, P.; SILLIERES, P.: "Le peuplement du Bas Segura de la Protohistorie au Moyen-Âge (prospections 1989-1990)" *Lucentum*, 17/18: 25-74.

Acknowledgements: This paper has been prepared as part of the research project «Agricultural landscapes. Systematization, analysis and typification of the landscapes formed by man's agricultural activities in Spain» (SEJ2006-15331-C02-02/GEOG), funded by the Spanish Ministry of Education and Science. MEDSPAI (MEDio, Sociedad y PAIsaje = *Environment, Society and Landscape*) is a research group of Departamento de Análisis Geográfico Regional y Geografía Física – Instituto Universitario de Geografía. University of Alicante.